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Technical Note 47

AN IMPROVED HYDROGEN ATOM BEAM FURNACE

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Ralph Klein and John Pararas

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AN IMPROVED HYDROGEN ATOM BEAM FURNACE

Ralph Klein and John Pararas

An improvement in the construction of the tungsten furnace for use in a hydrogen atom-beam apparatus has been effected by fabricating the furnace from a tungsten rod. This avoids the possibility of leakage of molecular hydrogen which may occur when the tungsten tube is made from rolled tungsten sheet, the technique used heretofore. The fabrication of the seamless furnace and the method of mounting are described.

INTRODUCTION

In many applications of atom beam techniques involving hydrogen, it is desirable to minimize the molecule-atom ratio of the beam. Several experimental considerations affect this ratio such as the design of the vacuum system and the construction of the furnace in which the hydrogen is dissociated. It is the latter problem which will be considered in some detail.

Experiments in which surface reactions of hydrogen atoms could be observed with a field emission microscope technique required an apparatus in which a field emission microscope tube, operating at liquid helium temperature, was attached to a hydrogen atom beam source. Considerable simplification in the interpretation of the field emission patterns would result if the percentage of hydrogen molecules in the impinging beam were maintained at as low a level as possible. Further, since the emitting point presents a target of the order of 10^{-8} sq. cm, a serious problem of the beam location can be avoided only if the beam cross section is sufficiently large. The intensity need not be high since even a fraction of a monolayer deposited on the emitting tip is easily observable. Considerations of this nature dictate the dimensions of the furnace, and in particular the size of the hole through which the atom effusion occurs.

Lamb and Retherford[1] describe, in their notable paper on the fine structure of hydrogen, a hydrogen dissociator made by rolling .004" tungsten sheet in the form of a cylinder. A slot cut near the center provided the hydrogen outlet. It is pointed out, in the authors' description of this furnace, that there is leakage of molecular hydrogen around the ends of the cylinder. Fite[2] employed a similar technique, using however,

1 Lamb, W. E. and Retherford, R. C., Phys. Rev. 79, 549 (1950).
2 Fite, Wade L., "Ionization of the Hydrogen Atom on Electron Impact", General Atomics Report GA267, Dec. 20, 1957.

0.001" thick tungsten foil rolled into 3/16" diameter tubes with six layers of foil making up the tube walls.

It is advantageous to construct the tungsten furnace from a solid tube with an axial hole and an appropriate central exit slot. That these have not been employed previously is to be ascribed to difficulties in fabrication. These difficulties have now been resolved, and the preparation of tungsten tube furnaces can be accomplished.[1] Fig. 1 is the design adopted for the application described. The furnace is made as follows: The starting blank is a tungsten rod, in this case .247" diameter. A blind hole, coaxial with the rod, is drilled with a hole .187" diameter, .062" deep being provided at the open end. The tube is then ground to give a .005" wall, as shown in the figure. Finally, the effusion hole is bored through the wall.

The success of drilling the long, narrow hole in the center of the tungsten rod depends to a great extent on the skill and experience of the fabricator. A tungsten carbide drill (carballoy 883) is used. It is shaped as shown in Fig. 2. The rod is mounted in a lathe and spun at 700 to 900 rpm, the drill being held in the tail stock. As the drilling proceeds, frequent removal of chips with a compressed air blast is required. It is important that the drill be resharpened frequently. The hole is made first with a roughing drill and completed with a finishing drill. About 8 hours are required to complete the operation.

The wall of the tube is ground to a thickness of .005" with an alundum wheel and a sulfur base lubricant. The tube is held with a mandril of high-speed steel specially ground to accurately fit the hole in the tungsten rod. The mandril is taper locked for the grinding process. The effusion hole is drilled through the wall as the final operation on the tungsten tube. During this process, the high-speed steel mandril is replaced with a similar one of cold rolled stock. The hole may be of any size depending on the requirements of the experiment. A fine slot may be drilled if a rectangular effusion orifice is desired.

The furnace was mounted as shown in figures 3 and 4. Platinum brazing of the tungsten to the molybdenum tube proved quite satisfactory. The molybdenum tube, surrounded by two concentric cylinders for water cooling, provides for passage of molecular hydrogen (introduced through a palladium thimble) to the dissociator. The blind end of the tungsten tube is clamped by a setscrew in a molybdenum holder. The holder in turn is setscrewed to the double copper coil as shown. Water circulating through these coils provides for cooling. The molybdenum holder moves freely in a stainless steel block, thus providing for the thermal expansion of the tungsten tube.

The tungsten tube furnace is heated with alternating current from a high current transformer, the primary of which is energized by a constant voltage supply. The leads are attached to the cooling tubes, one end of

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1 The technique was devised by Mr. William Stadler of N.B.S.

the furnace being electrically isolated from the assembly head by the "alsimag" gasket, as shown in figure 2. A current of about 175 amperes with a 1-1/2 volt drop provides a steady state furnace temperature of approximately 2300°C. The temperature has been maintained at this level for eight hours of continuous operation on several occasions, and the performance of the equipment has satisfactorily fulfilled design expectations.

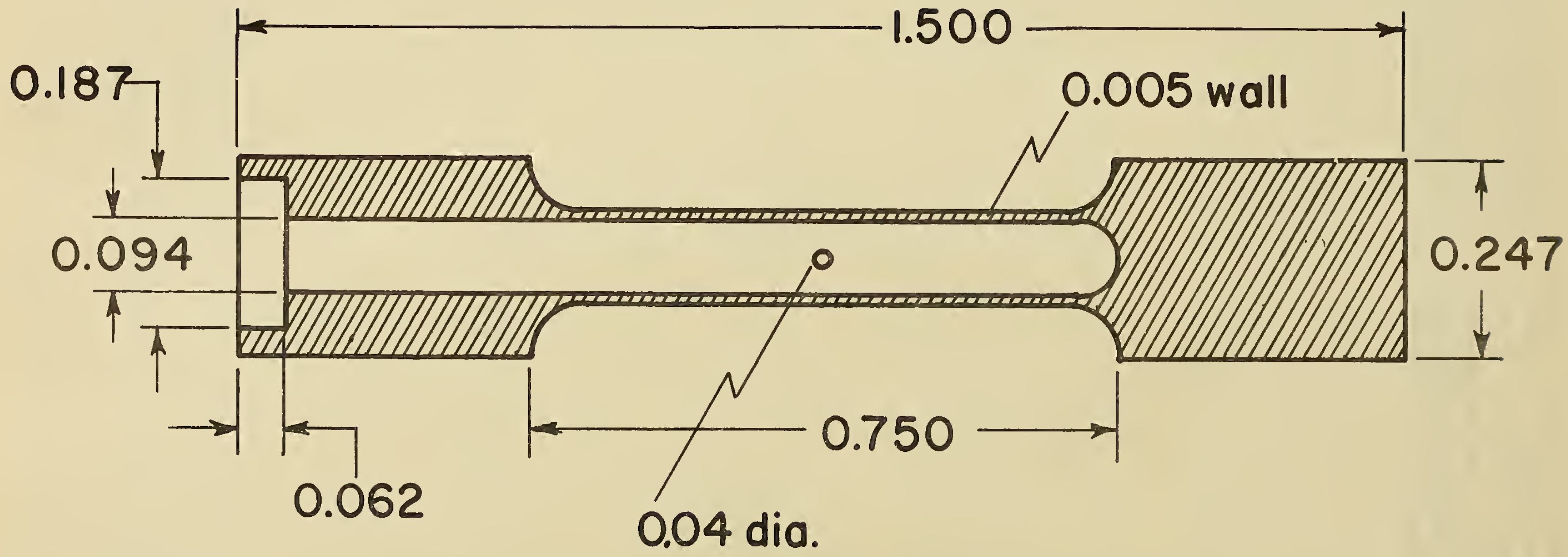

Fig. 1. Tungsten tube furnace for dissociating hydrogen.

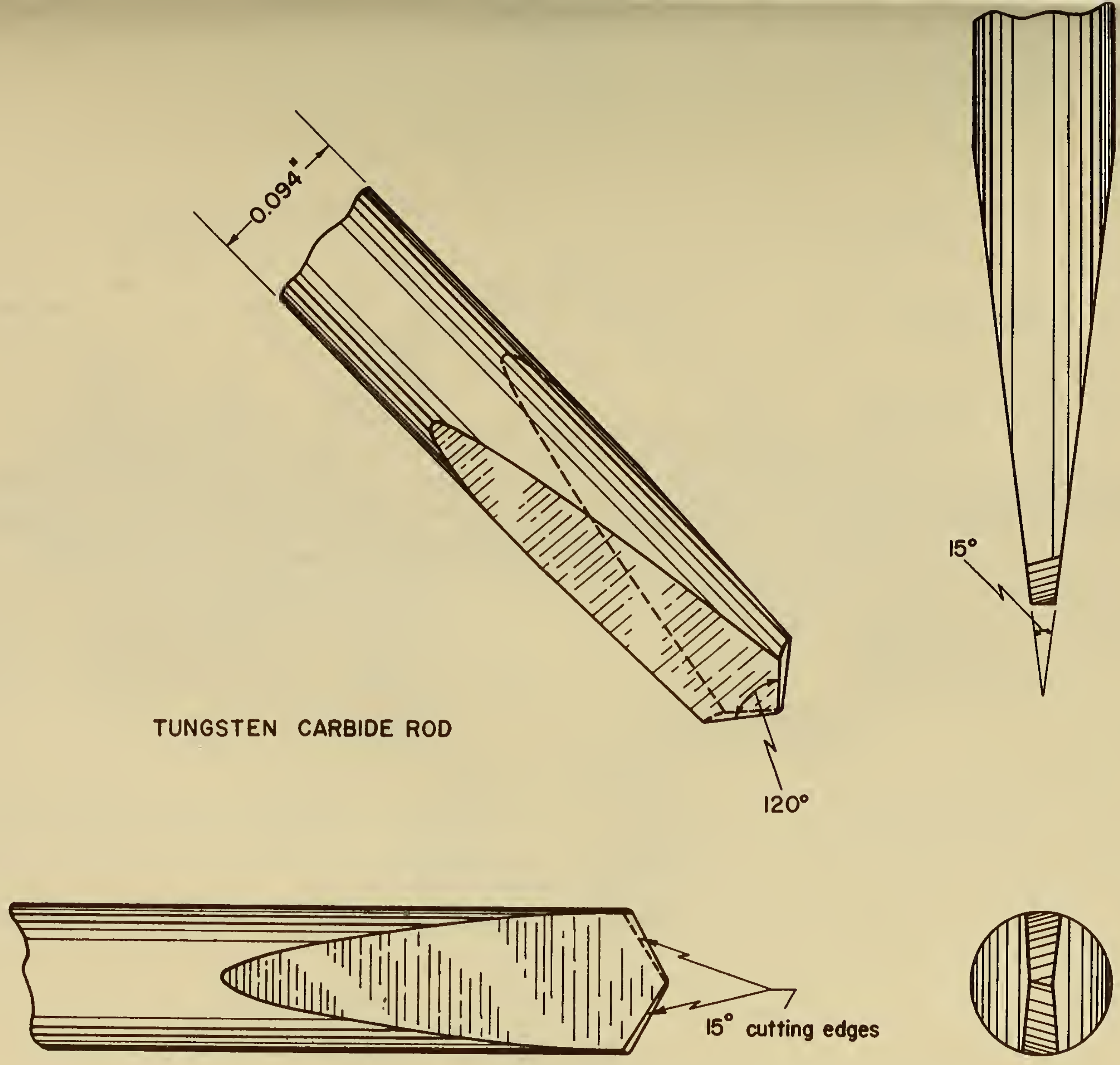

Fig. 2. Tungsten carbide tool for drilling the longitudinal hole in the tungsten tube furnace.

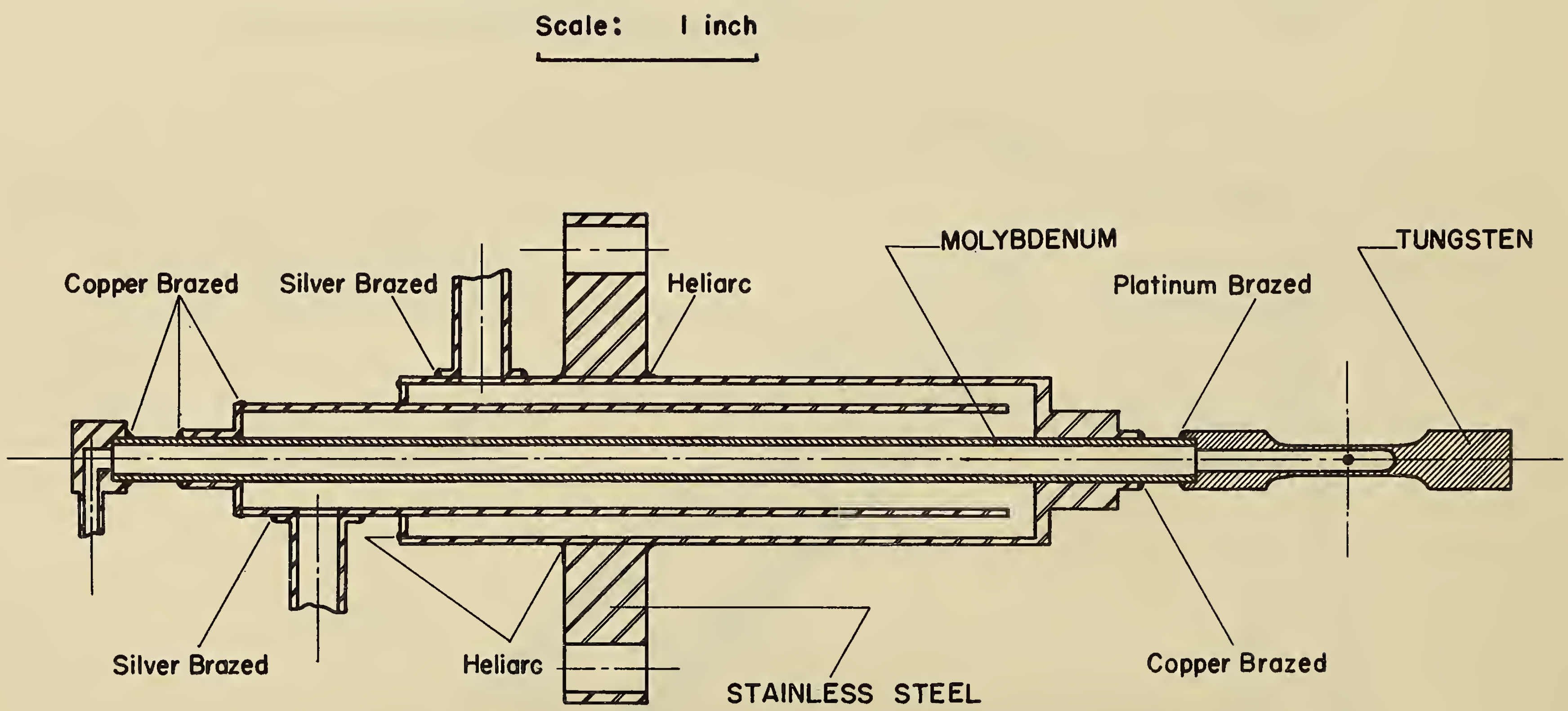

Fig. 3. Mounting of tungsten tube with hydrogen inlet system.

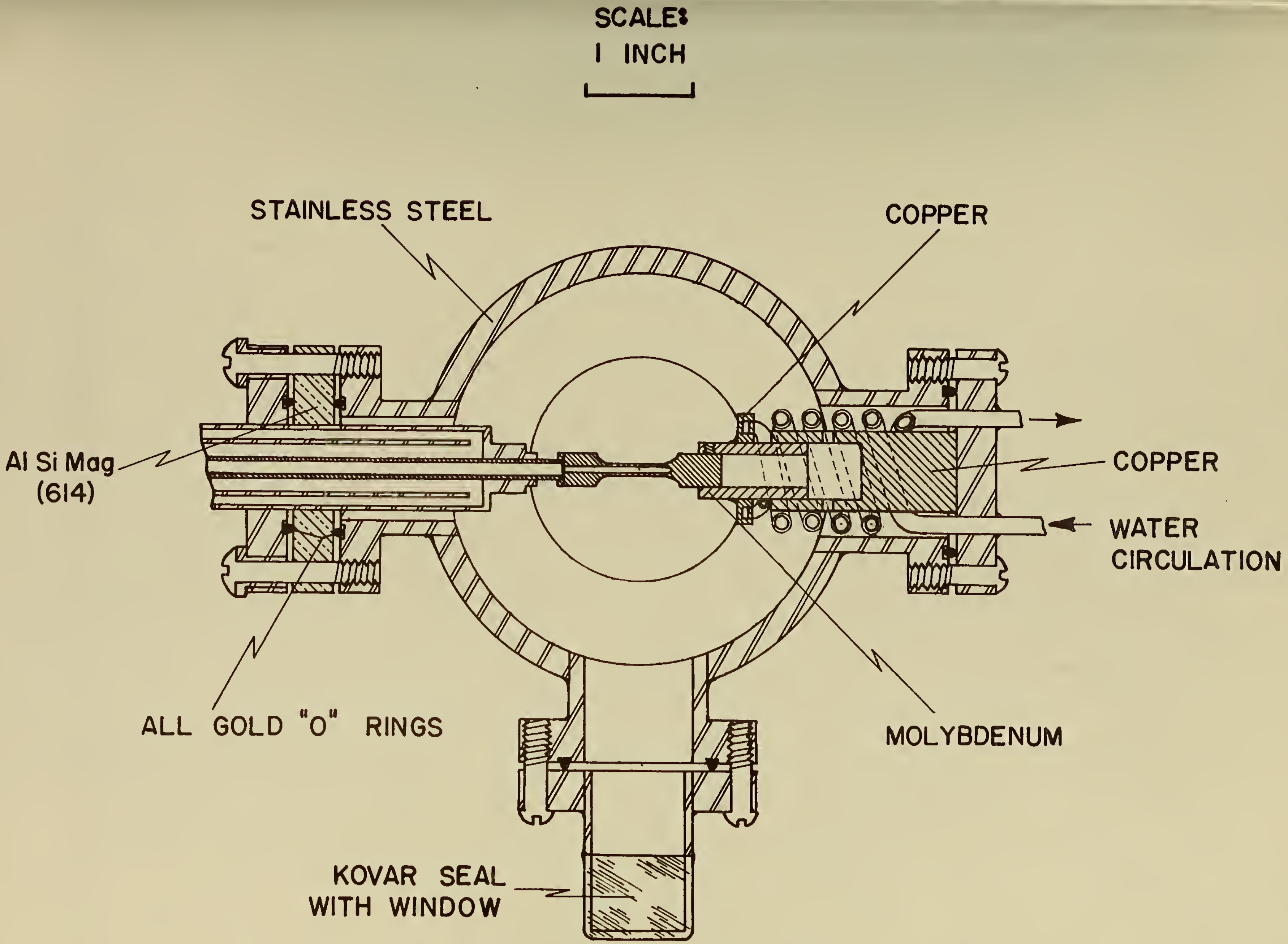

Fig. 4. Complete mounting of the hydrogen atomic beam source.

U.S. DEPARTMENT OF COMMERCE
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THE NATIONAL BUREAU OF STANDARDS

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- Office of Weights and Measures.

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